TCL 99-018

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METHOD OF DISTRIBUTING COMMUNICATIONS WITHIN A CELL OF A RADIO-COMMUNICATION NETWORK, AND A CORRESPONDING DEVICE AND BASE STATION

The field of the invention is that of radio-communications.

More precisely, the invention relates to the problem of saturation of the radio-communication cells, linked to the number of channels available within the cell and to the maximum transmission power of the base station associated with each cell of the network.

It will be recalled that cellular telecommunications networks are constituted by a meshing of their area of coverage into geographic areas of smaller size called cells. These cells themselves are generally sub-divided into geographic sectors. Traditionally, as shown in Figure 1, a cell 10 is divided into three sectors 111 to 113, each with an angular aperture approximately equal to 120°.

Each cell 10 corresponds to the geographic area covered by a base station 12, which transmits and/or receives signals to and/or from radio-communication terminals 13 present in the cell.

An important problem inherent to radio-communication networks is that the number of communications that can be established, in one cell, between a base station and the various radio-communication terminals present in the cell, is limited. This limitation is linked, on the one hand, to the maximum number of available channels in the cell, and, on the other hand, to the maximum power that the base station can transmit.

According to one known technique, a predetermined number of communication channels is generally attributed to each of the sectors of a cell. A disadvantage of this technique of the prior art is that, as soon as all the channels attributed to a

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sector are used, any new request for a terminal present in the sector and wishing to establish a communication, is refused.

Consideration has been given to allocating distinct levels of priority to the radio-communication terminals. In this way, when a terminal with a high level of priority transmits a request to open communication, it can have access to channel of communication at the expense of a low priority terminal, which is then compelled to put an end to its communication.

A disadvantage of this technique from the prior art is therefore that within a sector, one can only satisfy a limited number of requests to open communication, even if communication channels are available in other sectors of the cell.

In addition, the number of communications that can be set up in one cell is also limited by the maximum power that the base station can transmit, because of an interference phenomenon.

At present, two sources of interference can be distinguished.

On the one hand, the signals transmitted within a sector, by the radio-communication terminals or by the base station are propagated partially into adjacent sectors, belonging to the cell under consideration, or into a neighbouring cell. Within a given sector, interfering signals coming from adjacent sectors are therefore added to the wanted signals in the form of inter-sector interference.

On the other hand, within a given sector, a radio-communication terminal represents a potential source of interference for the neighbouring terminals, since the signals intended for a particular terminal are also received by all the neighbouring terminals, and thereby constitute intra-sector interference.

It is therefore clearly apparent that, the greater the number of terminals in communication in a cell, the more important are the inter-sector and intra-sector interference

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phenomena. Indeed, in order to compensate for these interference phenomena and to maintain a good signal to noise ratio for all the communications within a cell, it is necessary to increase the transmission power of the base station of the cell under consideration. When the interference is too great, which is particularly frequent in the case of CDMA (Code Division Multiple Access), the transmission power required at the base station to obtain a signal to noise ratio that is adequate for reception, can become too great and can therefore lead to saturation of the base station.

Therefore, another disadvantage of techniques of the prior art is that, because of an interference phenomenon, the number of communications that can be established within one sector is limited, even if communication channels remain available within the sector.

An object of the invention is, in particular, to remedy these disadvantages of the prior art.

More precisely, an object of the invention is to provide a radio-communication cell in which the communications are distributed in a more homogeneous manner between the various sectors.

Another object of the invention is to implement a method of distributing communications within a radio-communication cell which is simple and inexpensive.

Yet another object of the invention is to enable one to satisfy a greater number of requests for opening communication within one cell.

A further object of the invention is to provide a radio-communication cell within which the total power radiated by the base station is transmitted in a more homogeneous manner in all the sectors of the cell.

Yet another object of the invention is to set to work a radio-communication cell within which the communications are of better quality and, in particular, within which the effects of interference are reduced.

Yet another object of the invention is to permit a better distribution of the communications within a radio-communication cell, without having to modify the parameters or the structure of the radio-communication terminals of the network.

These objects and others which will become apparent in what follows have been achieved according to the invention, using a method of distributing the communications established by the radio-communication terminals, within a geographic cell of a radio-communication network, the geographic cell being sub-divided into at least two geographic sectors, comprising a step of modification, by rotation, of the orientation of the sectors within the cell.

Hence the invention rests on a completely novel and inventive approach to the management of the geographic cell of a radio-communication network.

In effect, the invention rests, in particular, on a dynamic definition of the sectors of a radio-communication cell, covering an expandable geographic area, as a function of the number of communications established within the sectors of the cell. Advantageously, the boundaries of the various sectors of a cell can be displaced, by simple rotation, in such a way that a more homogeneous distribution of the number of terminals in communication in each one of the sectors is obtained.

The invention is advantageously applicable to all types of radio-communication network and notably those to GSM (Global System for Mobiles), UMTS (Universal Mobile Telecommunication System) and CDMA (Code Division Multiple Access) Standards.

Advantageously, the step of modification is implemented according to at least one of the techniques belonging to the group comprising :

– the mechanical rotation of transmission antennae and/or reception antennae, each of the antennae being associated with one of the sectors of the cell ;

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– the reconfiguration of at least one network of smart antennae, each of the beams being associated with one of the sectors of the cell.

In effect, the modification of the orientation of the sectors of the cell can be carried out by mechanical rotation of a set of transmission antennae and/or reception antennae. Each antenna being associated with one of the sectors of the cell, the rotation of a given antenna leads to modification of the geographic area with which the corresponding sector is associated.

One may also implement the reconfiguration of a network of smart antennae, in the case where this technology is used by the operator of the radio-communication network. Each beam of the antenna being associated with one sector of the cell, it is clearly apparent that modification of the orientation of a beam leads to modification of the orientation of the associated sector.

According to an advantageous technique of the invention, the modification step is implemented if at least one command criterion for the rotation is satisfied.

Hence, when it is desirable to proceed with a modification of the orientation of the sectors, so as, for example, to distribute in a more homogeneous manner the communications within the cell, a corresponding criterion is satisfied and commands the implementation of the modification step.

Advantageously, said at least one command criterion for rotation belongs to the group comprising:

– total rate of at least one of the sectors is greater than a predetermined total rate ;

– the number of links established in at least one of the sectors is greater than a predetermined number of links.

These two criteria are in effect linked to the two factors limiting the number of communications that can be established, in one cell, between a base station and the various radio-communication terminals present in the cell, namely the

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maximum number of channels available within the cell, and the maximum power that the base station can transmit.

According to one advantageous characteristic of the invention, the modification step is only implemented if at least one of the following conditions is verified :

- the total rate of at least one of the sectors is less than the total predetermined rate;
- the number of links established in at least one of the sectors is less than the predetermined number of links.

In effect, if all of the sectors of a cell are saturated, that is to say if all the channels of communication of each of the sectors are used and/or if the total rate of each of the sectors is greater than or equal to the maximum authorized total rate, it is clearly apparent that implementation of the modification step is of no use. In such a case of saturation, the rotation of the sectors of the cell would not permit one to provide a more homogeneous distribution of the communications within the cell.

According to an advantageous technique, the method according to the invention comprises the following successive steps :

- Step A : detection of the sector or sectors of said cell for which at least one command criterion is satisfied ;
- Step B : selection, from among the detected sector or sectors, of one sector in accordance with a first predetermined strategy ;
- Step C : determination of a sector, from among the sectors adjacent to said selected sector, in accordance with a second predetermined strategy ;
- Step D : modification, by rotation, of the orientation of the sectors of the cell through one predetermined angular step, of said selected sector towards said determined adjacent sector in a way that creates new sectors within said cell ;

– Step E : detection of the new sector or sectors of said cell for which at least one tracking criterion relating to said selected sector is satisfied ;

– Step F : if no new sector has been detected during Step E, reiteration of Step D ; if not, a new position for the sectors of said cell is established.

Hence, a first step A enables one to detect the saturated sector or sectors of the cell. A second step B consists of choosing from among the sectors detected, the main sector from which load will be removed (that is to say, the sector whose communications load will be lightened thanks to carrying out rotation of the sectors). Next, step C allows one to select one of the sectors adjacent to the sector chosen in step B, to which the load of the chosen sector will be partially transferred, during step D of modifying the orientation of the sectors of the cell. Next, steps E and F consist of determining, according to a predetermined tracking criterion, if it is necessary or not to reiterate the modification step D.

According to an advantageous variant of the invention, the first predetermined strategy consists of selecting the sector for which the total rate and/or the number of links established is the greatest, the second predetermined strategy consists of determining the sector adjacent to the selected sector for which said total rate and/or the number of links established is less great, and said at least one tracking criterion relating to the selected sector belongs to a group comprising :

– the rate of the detected sector is greater than or equal to the total rate of the selected sector;

– the number of links established in the detected sector is greater than or equal to the number of links established in the selected sector.

Hence, during step B (respectively during step C) the sector with the greatest load is chosen (respectively the adjacent sector with the least load) in terms of total rate and/or the number of established links. If, after the modification step,

there is at least one of the new sectors of the cell whose load, in terms of rate and/or the number of links, is greater than or equal to the load of the sector chosen during step B, a new position is then established, and it is not necessary to reiterate the modification step.

According to an advantageous characteristic of the invention, the cell being sub-divided into three sectors, the modification step is not implemented if two sectors have an identical total rate and/or an identical number of established links, the total rate and/or the number of established links being respectively greater than the predetermined total rate and/or the predetermined number of links.

It is clearly apparent that, in the case where two sectors of a cell with three sectors, have the same level of saturation in terms of total rate and/or the number of established links, the implementation of a modification step does not enable one to distribute the number of communications within the cell in a more homogeneous manner.

Advantageously, during the modification step, the speed of rotation of the sectors is matched to the time for carrying out a transfer of communication from one sector to another.

Hence, a terminal which finds itself approximately at the boundary between two sectors before the modification step, and which would therefore compel the switching from a first to a second sector, because of the change in orientation of the sectors, advantageously has the time to carry out a transfer of communication from the first to the second sector. Such a characteristic thereby reduces the risk of accidental interruption of communication during the modification step.

The invention also relates to a device for distributing communications established by radio-communication terminals, within a cell of a radio-communication network, using means of modifying, by rotation, the orientation of the sectors of the cell.

The invention further relates to a base station of a cell of a radio-communication network, implementing a method of

distributing the communications such as that mentioned above and/or comprising a device such as that mentioned above.

Other characteristics and advantages of the invention will more clearly become apparent on reading the following description of a preferred embodiment, given purely by way of a simple illustrative example and being non-limitative, and the appended drawings among which :

- Figure 1 illustrates a cell of a radio-communication network sub-divided into three sectors with angular apertures equal to 120° ;
- Figures 2a and 2b show the implementation of the rotation of geographic sectors, in a radio-communication cell similar to that in Figure 1, in a manner that provides a more homogeneous distribution of the communications within the cell ;
- Figure 3 illustrates a radio-communication device that permits one to modify, by rotation, the orientation of the sectors of a cell, according to Figure 1 ;
- Figures 4a and 4b show a general synoptic chart of the invention in the form of a succession of steps implemented in two possible embodiments of the invention.

The general principle of the invention rests on the modification, by rotation, of the orientation of the sectors of a radio-communication cell.

An embodiment of a device that enables one to modify, by rotation, the orientation of the sectors of a geographic cell of a radio-communication network is given, making reference to Figure 3.

The device comprises a fixed part 32, integral with a support 34, and a movable part 33, able to pivot with respect to the fixed element 32 in the direction of the arrow 35. In this example, a set of three transmission antennae 311, and a set of three reception antennae 312 are fixed to the movable part 33. Each of these six antennae 311 and 312 is therefore a transmission or a reception antenna for one of the three sectors

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of the radio-communication cell. It is clear however that the invention can be implemented during reception only or transmission only. Hence when one wishes to modify the orientation of the geographic sectors of one cell, the element 33 is turned through a predetermined angle in the direction of the arrow 35 in a way that causes the two sets of antennae 31 to pivot. Each antenna 31 then covers a new angular sector, which permits the defining of a new geographic sector of the cell.

Such a device enables one to implement the modification of the orientation of the sectors of a geographic cell by mechanical rotation of transmission antennae and/or reception antennae associated with the cell under consideration. Another embodiment (not represented) can consist, for example, of reconfiguring a network of smart antennae. In this case, each beam covers one sector in transmission or in reception.

Referring to Figure 4a, the succession of steps is now shown for the implementation of one particular embodiment of the invention. A geographic cell is considered, divided into N sectors numbered S_1 to S_N. In a first possible embodiment of the invention, the rotation of the sectors of the cell is implemented if one of the sectors satisfies a predetermined total rate criterion. In effect, the notion of total rate of a sector and hence of maximum power transmitted by the base station associated with the cell, is directly linked to the phenomenon of interferences previously described.

During a first step 41, a device which may be, for example, the base station associated with the cell, calculates the total rate Rate(S_i) associated with each of the sectors S_1 to S_n of the cell, and compares the value Rate(S_i) to a predetermined value Rate_Max. The value Rate_Max corresponds to a maximum rate allowed for a given sector. This value is, for example, imposed by the operator of the radio-communication network under consideration. In the case of radio-communication networks to the UMTS (Universal Mobile

Telecommunication System) standard, the maximum total rate on a carrier is, for example, approximately equal to 2 Mbits/s.

If no sector S_i of the cell has a total rate greater than or equal to Rate_Max, step 41 is reiterated.

In the contrary case, in the course of a step 42, the sector S_{sat} having the greatest total rate is chosen from among the sectors detected during step 41.

In a step 43, the total rates Rate(S_i) of the two sectors S_{sat-1} and S_{sat+1} adjacent to sector S_{sat} are measured.

Step 44 allows one to determine, from among the two sectors S_{sat-1} and S_{sat+1} adjacent to sector S_{sat}, the sector S_{min} having the least total rate (S_{min} is such that $Rate(S_{min}) = min(Rate(S_{sat-1}), Rate(S_{sat+1}))$).

In the course of step 45, rotation of the sectors of the cell is implemented. The angular step of the rotation is a predetermined angle α, for example fixed by the operator of the radio-communication network under consideration. In this embodiment of the invention, the rotation occurs in the direction from the sector S_{sat} towards the sector S_{min}. After rotation, therefore, a new sub-division of the cell into N sectors designated S'_1 to S'_N is obtained.

Step 46 then consists of measuring the total rate Rate(S'_i) for each of the new sectors S'_1 to S'_N of the cell.

In the course of step 47, it is then determined if there exists a sector S'_i having a total rate greater than or equal to the rate of the sector S_{sat}. If no sector S'_i from among the sectors S'_1 to S'_N validates the relationship $Rate(S'_i) \geq Rate(S_{sat})$, then step 45 is reiterated.

If, on the other hand, at least one of the new sectors S'_i has a total rate greater than or equal to the rate of the sector S_{sat}, a new position of the sectors of the cell is then established in the course of step 48.

In effect, this signifies that the communications established in the cell, have then been redistributed in a more

homogeneous manner between the various sectors as Figures 2a and 2b illustrate.

In Figure 2a, a geographic cell 10 is divided into three sectors 111 to 113 with angular apertures of 120°. For example, nine communications 21 have been established in a first sector 111, three communications 21 established in a second sector 112, and two communications 21 established in the third sector 113. The implementation of the first embodiment described above advantageously allows one to modify the orientation of the sectors 111 to 113 by rotation through an angle α, as illustrated by Figure 2b in such a way that six communications 21 are grouped together in a first sector 111', five communications 21 in a second sector 112', and three communications 21 in the third sector 113'.

According to the first embodiment shown in relation to Figure 4a, step 41 of the method is then reiterated after a period of time T, fixed for example by the operator of the radio-communication network, and introduced during a time delay step 49.

The succession of steps implemented in a second embodiment of the invention will now be described in relation to Figure 4b. Once again, a geographic cell is being considered which is divided into N sectors numbered S_1 to S_N. In this second possible embodiment of the invention, the rotation of the sectors of the cell is implemented if one of the sectors satisfies a predetermined criterion, relating this time to the number of links established in this sector. By established link, one understands here the use of a communication channel by a terminal present in the sector. In effect, the number of channels available, and therefore the number of links established in one sector by the radio-communication terminals is a limiting factor to the maximum number of communications that can be simultaneously made within a given sector.

The succession of steps implemented in this second embodiment is similar to the succession of steps implemented

in the first embodiment illustrated by Figure 4a, the criterion of total rate Rate being systematically replaced by a criterion relating to the number of links established in a sector of the cell, designated NbLinks.

In the second particular embodiment described above, one can add an additional step $41'_{bis}$ between steps 41' and 42', in the course of which, one checks that there exists at least one sector S_i of the cell for which the number of links established is less than the number NbLinks_Max of channels of communication available in the sector. If such a sector exists, the method is progressed by passing to step 42'. In the contrary case, step $41'_{bis}$ is reiterated until at least one of the sectors of the cell is carrying less load, that is to say until at least one communication channel becomes free for at least one of the sectors of the cell.

In the same way, one may consider a new step 41_{bis} between steps 41 and 42 of the first embodiment described in relation to Figure 4a, in the course of which a check is made that there exists at least one sector S_i of the cell for which the total rate is less than the maximum authorized total rate Rate_Max. If such a sector exists, the method then proceeds by passing to step 42. In the contrary case, step 41_{bis} is reiterated until at least one of the sectors of the cell is carrying less load, that is to say until the total rate of at least one sector of the cell becomes less than the value Rate_Max.

In the traditional case where the geographic cells of a radio-communications network are sub-divided into three sectors with angular apertures equal to 120° (Figure 1), one may also implement an additional step 41_{ter}(and/or $41'_{ter}$) between steps 41 and 42 (embodiment No. 1) and/or between steps 41' and 42' (embodiment No. 2). During this additional step, a check is made that there are not two sectors selected during step 41 (and/or 41') carrying the same level of load, that is to say having an identical total rate (and/or having established an identical number of links).

One can, of course, envisage an embodiment variant of the invention in which steps 41_{bis} and 41_{ter} (respective $41'_{bis}$ and $41'_{ter}$) are both implemented between steps 41 and 42 (respectively 41' and 42'). One may also envisage an embodiment variation of the invention in which only step 41_{bis} (respectively $41'_{bis}$) is implemented between steps 41 and 42 (respectively 41' and 42') and an embodiment variation in which only step 41_{ter} (respectively $41'_{ter}$) is implemented between steps 41 and 42 (respectively 41' and 42').

Another embodiment variation of the invention can consist of combining the two embodiments previously described with the help of Figures 4a and 4b, that is to say, simultaneously taking into account two command criteria for the rotation of the sectors, namely a total rate criterion and a criterion relating to the number of links established in one sector. More generally, other criteria can be taken into account in order to refine the processing.

One may also envisage a succession of steps similar to that of the two embodiments previously described, the passage from one step to the following step being determined on the one hand, as a function of the total rate of a sector, and on the other hand, as a function of the number of links established in that sector. One can also consider weighting the command criteria for the rotation, as a function of the relative importance that one wishes to accord the total rate on the one hand and the number of links established on the other hand.